self with rod and line to which are attached 2 or 3 hooks very square in the bend and known as Cutla hooks, and watches the end of the bamboo.

When this twitches it indicates a fish nosing around and trying to get at the tit bits in the bamboo shell.

The hooks are carefully lowered until approximately under the fish, when a hard strike may result in it being foul hooked (Fig. 9)."

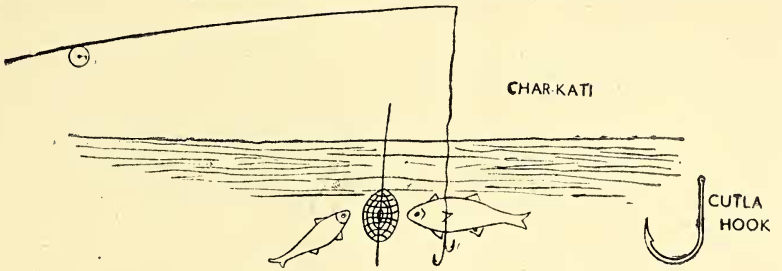


Fig. 9.—The 'Char-Kati' in action.

I have little to add to these notes except to say that a sound knowledge of the Code of the peacock quill, perfect co-ordination of eye, brain and wrist and patience in broiling sun or pouring rain are essentials to success in tank angling. The man who would 'chuck and chance it' had better stick to his spoon and rapid in some brawling Himalayan stream.

(*To be continued.*)

THE SENSE OF SMELL IN SNAKES.

BY

CAPT. ALLEN PAYNE.

(*With 2 plates and 1 text figure.*)

INTRODUCTION

The senses in the order Ophidia are very interesting, inasmuch as one finds according to the demands of food, protection, social life and the like, that one or more of the senses is to some extent exaggerated to compensate for the lack of, sometimes complete lack of, a particular sense.

This is most conveniently illustrated in the case of snakes by the fact that although a snake has no external auditory meatus and is to all intents and purposes quite deaf, they do possess a most uncanny sense of so-called 'hearing'. This is probably due to a very highly developed sense of 'feel'; nerve endings in the epithelium, scales and rib endings are developed *in excelsis*, even to the extent of recording minute vibrations. This high development and distribution of the nerves together with a very keen power of sight and extensive field of vision, is without doubt compensatory for the snake's deprivation of a sense of hearing.

Some years ago I interested myself in the sense of taste in snakes. As I was at that time in the United Kingdom, my speci-

mens were mainly obtained through the kindness of Dr. Burgess Barnett, at that time Curator of Reptiles at London Zoo. I was able to obtain python's heads from which I removed the tongues and prepared histological sections. These stained with haematoxylin and eosin did not lead me to believe that the python possessed any appreciable sense of taste as there was no evidence of the presence of taste buds in the epithelial layers. No doubt there is some other more highly developed power vested in pythons to compensate for this too.

A. F. Abercromby writing from Travancore on the 12th July 1921 to the Bombay Natural History Society[1] mentions that 'it is however doubtful whether the snake possesses much, if any, sense of taste'. He also mentions instances of snakes swallowing pieces of cloth and in one case a stick, which had recently been in contact with and absorbed the scent of rats. A most extraordinary appetite and palate! He was of the opinion that the snakes appreciated the smell of rats and took these articles to be them. The same writer records an incident of a python seizing and swallowing a rug. These observations however, do suggest a very powerful sense of smell in snakes.

It is well known from field observations that certain snakes quite definitely stalk their prey. The snake will be seen to make a meandering course, frequently flicking its tongue at objects and then proceeding on its way; eventually the snake will catch up with its objective and then depend on its keen visual powers and agility to effect capture.

Opinions are divided when it comes to the true function of the tongue, but in my opinion quite strong evidence is at hand to suggest that one of its major functions is the conveyance of scent spoors through the palatine openings into the internal nares.

In the same communication, Abercromby says, 'at any rate the tongue appears to act as the carrier of the scent to the nostrils'.

Reference should also be made to a most interesting paper presented by A. G. L. Frazer, I.M.D., on 'The Snakes of Deolali',[2] which includes an item, 'Note on the peculiar use made of the tongue by snakes and some lizards'.

He writes: 'A striking feature in the behaviour of a snake is the peculiar use it makes of its tongue. The cause of this seemingly purposive act is not generally understood. . . . The habit as noticed amongst the Ophidia synchronises with the exercise of muscular activity, such as locomotion, or when in the case of the cobra, the hood is expanded and the anterior third of the body is erected. It is only in these active states that the creatures shoot out the forked tongue in quick succession. The act appears to be in the nature of a physiological expression of some function serving to their benefit. The author is unaware of any scientific explanation for this characteristic behaviour. Any theoretical consideration offered in elucidation of the act must necessarily be advanced on some physiological ground. . . . Snakes being cold-blooded, their

[1] *Journal, Bom. Nat. Hist. Soc.*, vol. xxviii, p. 812.
[2] *Journal, Bom. Nat. Hist. Soc.*, vol. xxxix, p. 58.

temperature varies with the surrounding medium and is normally a degree or two above it. Any muscular output is always attended by heat production in the tissues and there must be some means for eliminating the heat engendered, especially in an animal which is totally unprovided with sweat glands. In view, therefore, of the fact that the act is a spontaneous one and associated with muscular activity alone, there are tenable reasons for believing that the heat formed in the tissues is got rid of by evaporation of the moisture from the extruded surface of the tongue.'

This is yet another theory of the function of the tongue, but I feel that the tongue has a more powerful role to fulfil in the life of snakes and it was the idea that the tongue is very closely connected with the olfactory organ that activated my interest to study the subject.

The following paper is a short study then, of the sense of smell in snakes, carried out over a period of about a year. The area from which I have drawn my specimens has been the United Provinces—mainly Lucknow district—and the species I have dealt with throughout the study has been the Common Krait (*Bungarus caeruleus*) as these are in abundance in this area and as I had promised to collect them in numbers to send to the Haffkine Institute, Parel, for antivenine research.

The major part of the investigation is based on twelve males and twelve females captured at village Kakori, U.P. The ages ranged between one year and two and a half years, and the males were between about three and four feet in length and the females two to three feet eight inches.

To make the discourse and the diagrams more clear, I have outlined very briefly the general anatomy and physiology of the organs of smell in snakes, and made special anatomical and histological observations in the case of *Bungarus coeruleus*.

Anatomy.

In any living creature the gustatory apparatus proper accommodates four main sensations, namely sweetness, salt, sourness and bitterness. These four sensations are but a mere portion of the wide range of sensations generally classified as taste. The appreciation of taste and smell is jointly derived from the sense of smell, which is subserved by the olfactory nerve.

Generally the organs of smell are two rather irregular chambers enclosed by the nasal capsules. These chambers are paired and separated by the nasal septum and are communicated with the internal nares; the linings of which are in connection with the olfactory nerves of each appropriate side.

In Ophidia, Jacobson's glands are present; these are situated between the nasal sacs and the palate, that is to say, between the turbinals and the vomer. They appear as a pair of sacs having an olfactory epithelium, and are actually outgrowths of the nasal sacs, innervated by the olfactory (and trigeminal). They open into the mouth immediately in front of the choanae and as such are consi-

dered as secondary olfactory organs specifically developed to serve the mouth. (See plate and diagrams of the mouth and skull.)

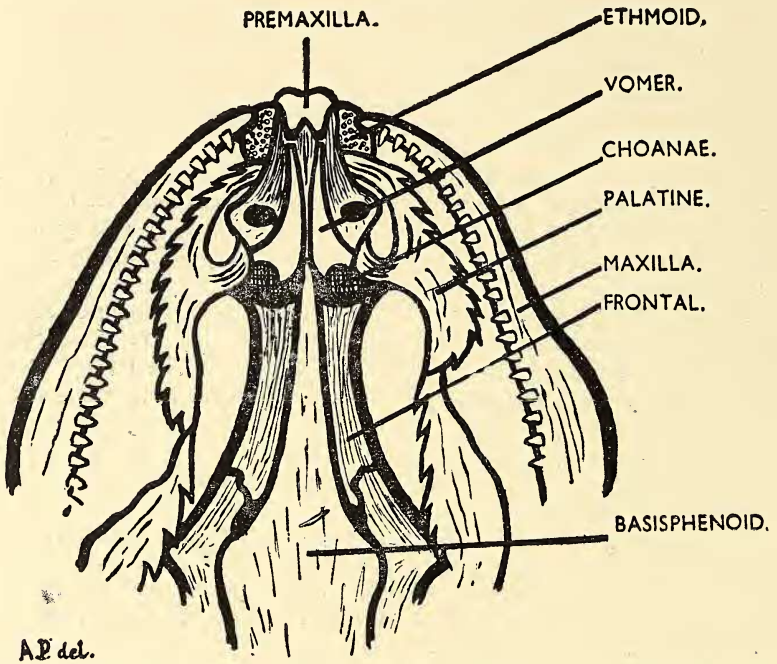


Fig. 1.—General idea of the anterior aspect (ventral) of a snake's skull showing the relationship of the vomer and choanae.

Anatomy of Bungarus caeruleus.

The general anatomy of the olfactory organ and its complimentary structures is not exceptional in the case of the Common Krait. An anterior palate, made up of thin tissue forming a sort of roof, is stretched across between the maxillae. Its length completes about one-third of the total tooth bearing maxillae and is rather short.

Leaving a space of about one-eighth of an inch above this, lies the roof of the mouth and the palate proper. Behind this tissue roof are the openings into the internal nares and the connections with the nostrils. (See plates.)

A note on nervous tissues.

Nerve tissue is made up of a series of cells which have the power of not only receiving but also interpreting stimuli. These cells are neurons and have a main body, a nucleus and radiating from the whole are many tails called dendrites with one particularly long dendrite known as the axon. It is along the axon that the nerve impulse passes. The axon eventually breaks up into tufts of many branches (terminal arborisation) and it is from here that the axon passes on the stimulus to either another cell or to fibres within the muscle, whence it is conveyed to the central nervous system. The axons sometimes become very long and come

Fig. 1.—Longitudinal section through the tongue of *Bungarus caeruleus*. (Note absence of taste buds.)

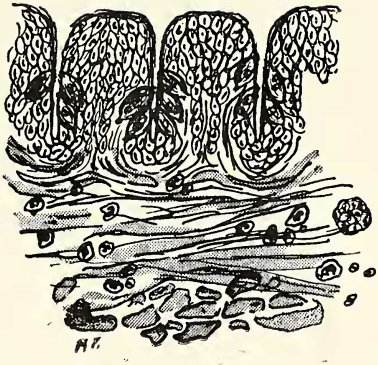


Fig. 2.—Longitudinal section through tongue of a rabbit showing taste buds in the epithelium.

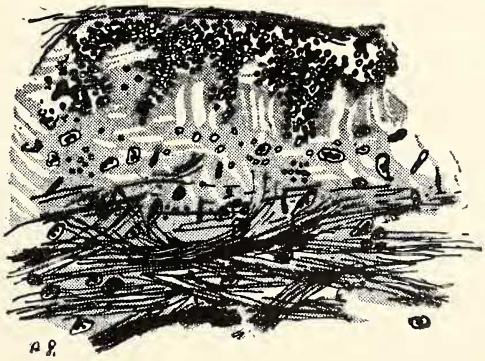
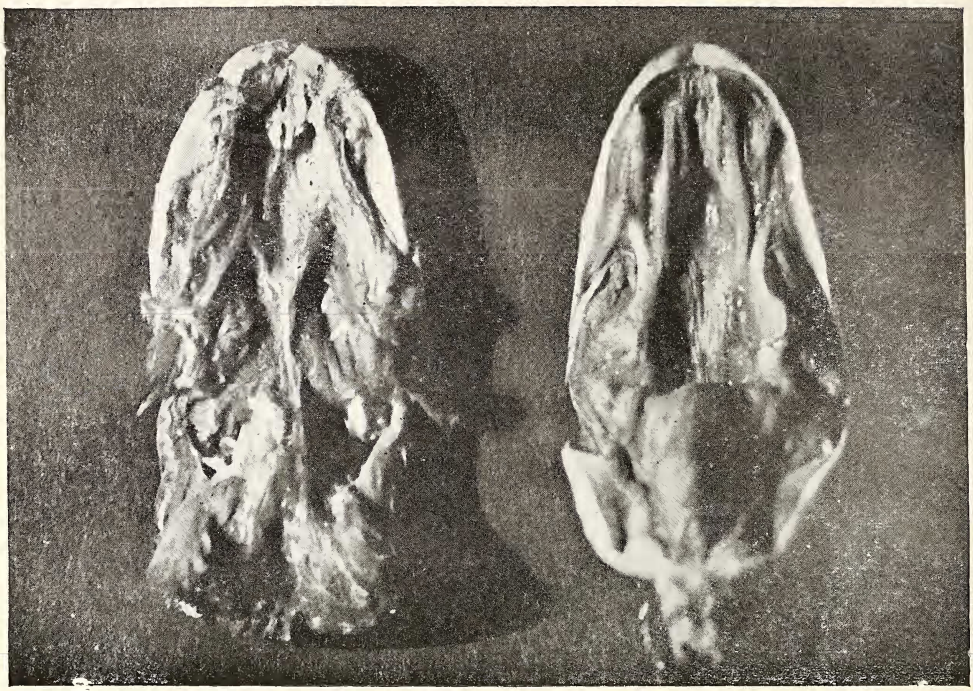
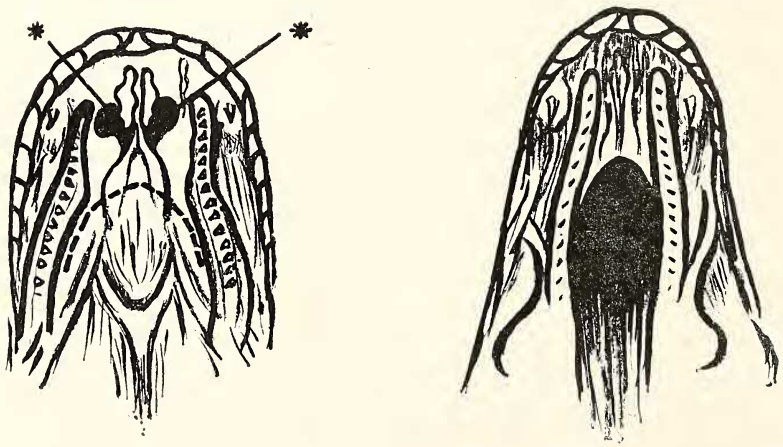


Fig. 3.—Portion of a longitudinal histological section of a piece of olfactory tissue from *Bungarus caeruleus* showing nerve fibres in section and bundles.



A *B*

Fig. 1.—Photograph of the palate of the Common Krait (*Bungarus caeruleus*). *A*. Dissected. *B*. Natural. *See explanation below.*



A *B*

Fig. 2.—Diagram in explanation of the photograph above.

A.—This shows the palate after the removal of the arch of tissue covering the openings into the nares (dotted line shows the original position of it). The openings into the nares are marked *.

B.—The natural palate showing the arch and the cavernous appearance of the roof of the mouth going beneath it.

together to form nerve fibres of which some tissue is made up. Usually the sense cells in the epithelium have a supporter cell lying on either side of them.

Physiology.

When air containing odorous particles is drawn through the nostrils or the mouth into the olfactory chambers, the cells known as receptor cells (which are particularly irritable to certain stimuli and line the nasal chambers) react to these odorous particles and the stimulus is passed to the afferent fibres, that is to say, those which pass through the dorsal root or one of the sensory cranial nerves, from whence they conduct the particular stimulus to the central nervous system.

A sensation is thus recorded.

Histology.

Specimens were dissected from the heads of both the male and female kraits and these were histologically sectioned as thinly as was possible and stained with haematoxylin and eosin and the nervous tissue stains.

First of all the tongue was sectioned (see plate) and this was compared with that of a rabbit. There were no traces whatsoever of any taste buds in the tongues of the snakes to suggest a sense of taste in these creatures. The plate will readily show the taste buds in the section of the rabbit's tongue; they lie within the epithelial papillae.

The snake's tongue demonstrates a wealth of epithelial cells and some muscular tissue.

Next, the olfactory was sectioned and proved to be most interesting on examination. Both the olfactory lobe and a portion of the nasal tissue were examined.

Generally the surface showed evidence of cross-sectioned nerve bundles overlaying many small granule-like cells with a few nerve fibres running in between them.

Dotted about the entire centre of the organ were many large nerve cells and although the sections were rather thick it appeared that these large cells were held together by strand-like structures or fibrils which were no doubt made up from the cell dendrites. Beneath these large cells many bundles of nerve fibres were seen containing a medley of cells.

The organ as a whole appeared to be well endowed with nerve cells and fibres and suggested a quite highly developed and efficient working olfactory organ.

EXPERIMENT NO. 1.

Sensitivity Tests.

A box was prepared, having a glass front and being divided centrally into two chambers. The dividing piece had in one bottom corner an aperture 3 inches by 3 inches, over which was hung a piece of damp cloth to cover it.

For the purpose of the experiments the left-hand chamber is to be known as 'A' and the right 'B',

The tests were carried out between about 8 p.m. and 8 a.m. In chamber 'A' a bowl containing slightly warmed concentrated Formaldehyde was placed and a male krait was also put in the same side. The vapour from the Formaldehyde did not appear to embarrass the snake for some time; the next morning, however, the krait had moved its abode by means of the aperture and was seen to be in chamber 'B' which was well ventilated. The experiment was repeated several times with males and females and most of them moved to the neighbouring chamber. Three died in chamber 'A', two being females.

I attribute the delay in any reaction to the fact that snakes appear to have the power of 'cutting off' their respiratory system on receipt of an unpleasant stimulus (Formaldehyde is more of an irritant than a bad smell) and also to the fact that the Formaldehyde vapour was of insufficient strength to more than irritate the nasal membrane in the first instance.

Similar experiments were carried out with other commodities and a table is appended to show the reactions.

Table showing the various reactions of Bungarus coeruleus to the given commodities.

Commodity	Snake	Sex.	Reaction
Formaldehyde	BUNGARUS COERULEUS.	5 ♂	4 from A to B. (1 died in A).
		5 ♀	2 from A to B. (2 died in A). (1 remained in A).
Decomposing vegetable matter...		4 ♂	Nil.
		4 ♀	Nil.
Petrol, Turpentine, Pyridine ...		4 ♂	2 from A to B.
		4 ♀	Nil.
Fresh wild flowers ...		5 ♂	1 from A to B.
		5 ♀	Nil.
Decomposed fly-blown krait covered with maggots ...		6 ♂	All to Chamber B.
		6 ♀	(Apparently to escape the maggots.)
Sulphur fumes		3 ♂	2 from A to B. (1 died in A.)
		3 ♀	1 from A to B. (2 died in A.)

There is no conclusive evidence that the movements were due to the snakes recording a bad stimulus by means of the olfactory organ but it is interesting to note that the males appeared more reactive than the females.

Samples of the commodities soaked into cotton wool and placed on the end of a stick were held over the nostrils of the snakes and the reactions were generally that the snake hid its head in its coils.

If the tongue actually touched the commodity the reaction was certainly more pronounced and rapid.

Experiment No. 2.

On February 4 two of my specimens were seen to be locked in coitus. The female was removed and the anal scent glands were carefully dissected. The dark black creamy substance therefrom was then removed and a line of it was streaked from 'A' to to 'B' through the aperture.

The male krait was placed in chamber 'A'. After about three hours he was seen to be in chamber 'B' exploring. This experiment was not repeated.

Whilst I do not believe that the anal gland has any significance sexually, as I do not perceive any macroscopical or histological change in it, and as insufficient data is available to prove that it is by this means that the male detects its mate,[1] I do feel that the krait was appreciative to the particularly pungent smell of the excretion from the glands.

Later, a corner of another box was smeared liberally with the same substance from the anal glands and be it by choice or coincidence, the entire kraits contained therein coiled themselves in that corner and if moved soon returned to the same spot.

Mr. S. H. Prater in his article 'The Social Life of Snakes' (*J.B.N.H.S.*, vol. xxxvi, p. 475) suggested that the function of the anal glands may be in the locating of the female by the male during the breeding or mating season; he adds that these problems require further elucidation.

Colonel Wall on the same subject writes: 'Anal Glands.—The anal or scent glands secrete a blackish material of the consistency of a soft ointment. This has a peculiar, rather disagreeable, but not very penetrating smell. The glands in the both sexes are active at all seasons, and at all stages from the time of hatching, so that I am inclined to question the popular belief fostered by Darwin (Descent of Man, p. 539) among others that they are concerned with the sexual functions.'

Conclusion.

From the anatomy of the palate and the olfactory organs it appears that there is a definite functional link between the two. The presence of the tissue stretched across between the palate and the mouth is suggestive of an attempt to collect odorous particles which enter the mouth by means of the tongue. The vapour therefrom would be conveyed through the narial openings to the internal nares lined with epithelium innervated by the olfactory.

In this connection the tongue undoubtedly plays an important role in being the method of transport of the odorous particles to the narial openings.

From the histology it would appear that the tongue has no appreciable sense of taste. Experimentally it is observed that although there is some reaction to certain commodities touched by the tongue, this reaction is due largely (that is, when the com-

[1] I have frequently dug for Kraits and found male and female paired during hibernation.